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ABSTRACT

The study of fractions is fundamental in mathematics, yet it is among the most difficult topics for school students. This digest discusses the issues that students face in studying fractions and offers a curriculum consisting of four modules for teaching about fractions. Information about the Rational Number Project, additional resources, and World Wide Web sites are also provided. (ASK)

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Curricula For Teaching About Fractions

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The study of fractions is foundational in mathematics, yet it is among the most difficult topics of mathematics for school students. Students have difficulty recognizing when two fractions are equal, putting fractions in order by size, and understanding that the symbol for a fraction represents a single number. Students also rarely have the opportunity to understand fractions before they are asked to perform operations on them such as addition or subtraction (Cramer, Behr, Post, & Lesh, 1997).

The *NCTM Curriculum and Evaluation Standards* (1989) promotes the use of physical materials and other representations to help children develop their understanding of fraction concepts. The three commonly used representations are area models (e.g., fraction circles, paper folding, geoboards), linear models (e.g., fraction strips, cuisenaire rods, number lines), and discrete models (e.g., counters, sets).

Some may believe that children will automatically understand fraction concepts simply as a result of using the various representations or manipulatives. This is not necessarily the case (Thompson & Lambdin, 1994). For instance, some students define a fraction as "a piece of pie to eat," because they have only seen fractions represented using circle diagrams (Niemi, 1996). Providing many kinds of representations can help students with this problem, as long as teachers help students connect their understanding of concepts to the different representations. This digest describes curriculum guides which offer help to teachers wanting to extend student ideas of fraction concepts, use manipulative materials in powerful ways, and help students connect fraction concepts.

Seeing Fractions

The *Seeing Fractions* unit (Corwin, Russell, & Tierney, 1990) exposes students to several visual models for fractions that represent the various contexts in which fractions are commonly used—to denote part of the area of a shape (e.g., 3/5 of a pizza), part of a group of things (e.g., six of the ten team members are girls), part of a length (e.g., 2/3 of the distance from home to school), or a rate (e.g., three candy bars for 50 cents). The unit is comprised of four modules, each representing one of these contexts. In the first module, students explore the fraction equivalencies of common fractions (halves, thirds, fourths, sixths, eighths, twelfths, and twenty-fourths) using geoboard-based activities. Particular emphasis is placed on encouraging students to generate many different examples of a partitioning of a unit whole (such as into fourths) that are equal in area but may not be congruent in shape. For example, half of a 4x4 geoboard may be divided into two congruent squares and the other half into congruent triangles. All pieces have an area of one-fourth of the whole, but are not all the same shape.

In the second module, students explore rates as a setting for developing procedures to compare fractions and to find equivalent fractions. Starting with scenarios such as selling candies (five for two cents) students learn to create equivalent fraction series (5/2 = 10/4 = 15/6 = ...) from a base rate (5/2). Using this knowledge they are able to compare two fractions (5/2 is greater than 5/3 since in their series table 5/2 = 15/6 and 5/3 = 10/6) and to solve proportion problems.

In the third module, students relate fractions to division in the context of sharing and as they develop strategies for adding fractions. An initial scenario suggests students generate plans for sharing seven cookies among four people. Students' strategies will likely fall into one of three categories: (1) give everyone a cookie, divide the rest in half and give everyone half, then divide the remaining cookie and give everyone a fourth; (2) divide all the cookies into fourths and give everyone one fourth from each cookie; (3) give everyone one cookie, then remove one fourth from each cookie and put it together so that each person gets another 3/4 of a cookie. The amount of cookie(s) that one person will receive can be represented by 1 + 1/2 + 1/4, 7/4, or 1 + 3/4, respectively. Student strategies for solving the problem provide a context for exploring addition of fractions as these representations must all yield the same amount.

In the fourth module, fraction strips are used to help students develop an understanding of what is meant by partitioning a whole length into equal fractional lengths, of estimating fractional lengths, and of measuring distances. Activities include estimating lengths of objects with unmarked strips, creating fraction rulers through strategies of equal partitioning such as paper folding, and comparing fractions by organizing fraction rulers in arrays.

Rational Number Project

The *Rational Number Project: Fraction Lessons for the Middle Grades* (Cramer et al., 1997a, 1997b) comprises two volumes of carefully researched lesson plans aimed at developing students' number sense for fractions. Level 1 is written for students in grades 4-5 and level 2 is written for grades 5-8. The model is based upon several key ideals. First, to develop fraction number sense, students must spend time investigating concepts of order, equivalence, unit, and addition and subtraction with manipulative materials, such as fraction circles, counters, Cuisenaire rods, and paper folding. Another aspect of the program is that each of the models used are analyzed to see how they are alike and different, and efforts are made to connect ideas across many different types of representations. This practice corresponds to the Lesh Translation Model (see Cramer, Behr, Post, & Lesh, 1997a or b).

Both level 1 and level 2 lessons emphasize developing the meaning for fraction symbols before asking students to operate on them. Except for the topic of multiplication of fractions and the introduction of a new, more complex model for fractions (Cuisenaire rods) in level 2 lessons, both sets of lessons cover the same topics.

Initial lessons in level 1 have students engage in modeling and naming (verbally and symbolically) fractions less than 1

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using area models such as fraction circles, paper strips, and other shapes. Throughout these initial lessons the concept of the flexibility of the unit is developed by using a variety of non-standard shapes to represent one whole such as half of a circle. Fraction equivalence and ordering are then introduced using area models before students are asked to develop the same concepts using a discrete model such as counters.

The next tier of lessons returns to the initial area models of fractions to develop students' ability to reconstruct the whole given a fractional part and to model and name fractions greater than 1. A subsequent lesson extends the concept of fraction equivalence using the rate series by having students look for number patterns in the information they have already gathered about equivalent fractions.

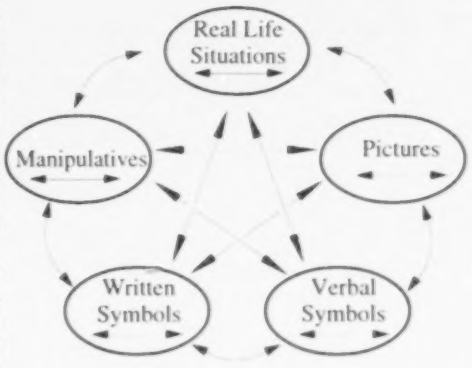
In the closing lessons, addition, subtraction, and multiplication (level 2 only) are introduced via students' modeling of stories. A special emphasis is given to students' estimation of the sums, differences or products by recognizing the approximate size of the fraction operands using their internalized visual models of fractions.

NCTM Addenda Series

The NCTM Addenda Series booklet *Understanding rational numbers and proportions* (Curcio & Bezuk, 1994) for grades 5-8 presents a collection of activities involving rational numbers and proportions in a problem-solving context. Many of the activities stress the application of rational numbers to real-world situations, the use of alternative assessment techniques, and the integration of technology. The activities are divided into three content clusters: exploring and extending rational number concepts, applying rational number and proportion concepts, and making rational number connections with similarity.

Summary

The key features of the curriculum materials described here are implicit in the Lesh Translation Model presented above. Students begin to construct a deeper understanding of fractions when they are represented in a variety of ways and when there are explicit linkages to everyday life and familiar situations involving the use of fractions. Other resources that facilitate these linkages are grouped here by topic.



Lesh Translation Model

Beginning fraction concepts

Leutzinger, L. P., & Nelson, G. (1980). Let's do it: Fractions with models. *Arithmetic Teacher, 27*(9), 6-11.
Presents beginning fraction concepts using a circle-region or "pie" model.

McBride, J. W., & Lamb, C. E. (1986). Using concrete materials to teach basic fraction concepts. *School Science and Mathematics, 86*(6), 480-488.
Describes how to prepare inexpensive materials.

Van de Walle, J., & Thompson, C. S. (1984). Let's do it: Fractions with fraction strips. *Arithmetic Teacher, 32*(4), 4-9.
Describes how to make fraction strips and presents beginning activities.

Multiplication of fractions

Sinicrope, R., & Mick, H. W. (1992.) Multiplication of fractions through paper folding. *Arithmetic Teacher, 40*(2), 116-121.
Uses an area model to show multiplication of fractions.

Cramer, K., & Bezuk, N. (1991). Multiplication of fractions: Teaching for understanding. *Arithmetic Teacher, 39*(3), 34-37.
Uses geoboards, paper folding, and counters to show multiplication of fractions concepts.

Division of fractions

Curcio, F. R., Sicklick, F., & Turkel, S. B. (1987). Divide and conquer: Unit strips to the rescue. *Arithmetic Teacher, 35*(4), 6-12 .
Uses teacher-made strips to show division ideas.

References

Corwin, R. B., Russell, S. J., Tierney, C. C. (1990). *Seeing fractions: A unit for the upper elementary grades.* Sacramento, CA: California Dept. of Education. (ED 348 211).

Cramer, K., Behr, M., Post, T., & Lesh, R. (1997a). *Rational Number Project: Fraction Lessons for the Middle Grades: Level 1.* Dubuque, IA: Kendall/Hunt Publishing.

Cramer, K., Behr, M., Post, T., & Lesh, R. (1997b). *Rational Number Project: Fraction Lessons for the Middle Grades: Level 2.* Dubuque, IA: Kendall/Hunt Publishing.

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Niemi, D. (1996). A fraction is not a piece of pie: assessing exceptional performance and deep understanding in elementary school mathematics. *Gifted Child Quarterly, 40*, 70-80.

Thompson, P. W., & Lambdin, D. (1994). Research into practice: Concrete materials and teaching for mathematical understanding. *Arithmetic Teacher, 41*(9), 556-558.

World Wide Web Resources

Math Archives: Topics in Mathematics
http://archives.math.utk.edu/topics/
Use the search engine on this page to find many fine resources about teaching fractions.

AskERIC Lesson Plans: Mathematics
http://ericir.syr.edu/Virtual/Lessons/Mathematics/index.html
Many lesson plans by topic in mathematics. Look under "Arithmetic."

Where To Go For More Information

There ERIC database includes bibliographic information on many documents and journal articles related to teaching about fractions. Use "Fractions" or "Decimal Fractions" as Descriptors to search the database at *http://ericir.syr.edu*.

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